HARNESSING THE BENEFITS OF GROUNDNUT AND TODDY PALM SHELL BIOCOMPOST ON SELECTED CROPS

SYNOPSIS

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INTRODUCTION

Agriculture play an important role in the world economy, particularly in India as many people are dependent on agriculture. Most farmers use chemical fertilizers for the cultivation of vegetables and seasonal crops. Chemical fertilizers are used to strengthen the fertility of the soil and increase crop yield. However, it had a negative impact on soil microorganisms, biochemical and geochemical cycles. The usage of toxic synthetic fertilizers plays a vital role in agro-ecosystem which causes various harmful effects like soil degradation, genetic diversity of crop loss, soil microorganisms reduction, groundwater resource contamination and atmospheric pollution (Erana *et al.,* 2019). The continuous routine usage of chemical fertilizers declines the yield of crops due to the soil acidification and loss of physico-chemical properties (Ghimire *et al.,* 2017). Hence, it is necessary to stop the conventional farming system and to practice agriculture through organic in order to reduce pollution and maintain healthy environment.

Organic agriculture is a holistic production management that promotes the biological cycle of soil and biodiversity (Vijayanand *et al.,* 2014) that uses fertilizers of organic origin such as compost manure, green manure, farmyard manure, biofertilizers and vermicompost which enrich the soil properties and promotes the crop growth and yield. Organic manures can serve as an alternative to mineral fertilizers for improving microbial biomass (Suresh *et al.,* 2004) and soil structure (Dauda *et al.,* 2008) which plays a direct role in plant growth as a source of all necessary micro and macro nutrients in available forms during mineralization (Chaterjee *et al.,* 2005). The use of organic fertilizer enhances soil physical, chemical and biological properties, and act as a good soil conservator by upholding its fertility, securing sustainable agricultural production and improving the quality of crop (Islami *et al.,* 2011; Adhami *et al.,* 2014). At the same time, we face another problem which is the disposal of agricultural wastes.

The disposal of solid waste is a prominent environmental problem all over the world. The improper disposal of wastes creates environmental pollution and vector-borne diseases spread by insects and rodents which inturn result in health hazards to human beings. The accrual of waste generated from industries, municipal solid waste, domestic waste and agricultural wastes in the form of liquid, slurry and solid depends on the nature of the waste. India generates 500 million tons of agricultural waste per year. Agricultural wastes are crop residues, weeds, leaf litter, straw waste and forest wastes which are disposed of by dumping or burning in the open field creating

environmental pollution.

Groundnut (*Arachis hypogea* L.) is one of the most common commercial crops cultivated throughout the tropical and sub-tropical parts of the world. Annually, 45.6 million metric tons of groundnut are produced globally. Every kilogram of groundnut produces around 250-300 g of groundnut shell (Zhao *et al.,* 2012). Groundnut shell is a waste product obtained after the removal of groundnut seeds from its pod (Usman *et al.,* 2016). Every year the production of groundnut has increased and simultaneously the waste materials also increased.

Toddy palm (*Borassus flabellifer* L.) is Tamil Nadu's state tree belonging to Arecaceae family. It is mainly grown for building materials, furniture, handicraft, medicinal purposes, beverages and as foods. The fruits are sedative, aphrodisiac, stomachic and laxative in nature. Almost all parts of the plant have economic value except their shells, about 70% of shells are considered waste. After separating the sweet jelly seed sockets, the fruit husk (shell) consists 40 - 50% of mesocarp and exocarp is thrown away or burnt in the open field creating environmental pollution (Rodiah *et al.,* 2019; Madhu *et al.,* 2016). To avoid this situation recycling is one of the best approaches for converting waste to wealth products.

Keeping all this in mind the current study deals with the impact of bio-composting of agricultural residues groundnut shell and toddy palm shell on plant growth performance of Bhendi (*Abelmoschus esculentus* (L.) Moench Var. Co 4), Cluster bean (*Cyamopsis tetragonoloba* (L.) Taub Var. MDU 1), Coriander (*Coriandrum sativum* Var. Co (CR) 4) and Fenugreek (*Trigonella foenum-graecum* (L.) semen Var. Co 2).

The fertility of soil is one of the most important characteristics for crop growth. For optimum plant growth, it requires a soil that provides deep rooting, good aeration, good water retaining capacity and contains an adequate level of plant nutrients. Nitrogen, phosphorus and potassium are the three most important macronutrients required for crop production. Plants need 16 elements (nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, boron, chlorine, iron, manganese, zinc, copper, molybdenum, hydrogen, oxygen and carbon) for successful plant growth, each one of which has one or more special functions in the growth and development of plants.

Organic farming helps to improve the quality of crops and reduce environmental pollution. Organic fertilizers increase the fertility of the soil, microbial activity and provide long term

nutrients by gradual decomposition (Angin *et al.,* 2017) which reduces the use of chemical fertilizers and pesticides. The current study will provide not only an alternate solution for the dispose of groundnut shell and toddy palm shell but also reduce the application of chemical fertilizers for sustainable crop production through organic agriculture.

Objectives of the study

- To evaluate the efficacy of bio-composted groundnut shell and toddy palm shell by microbial consortium, *Trichoderma asperelloides* and *Eisenia fetida*.
- To count the microflora present in the bio-compost.
- To study the physico-chemical and spectrochemical analysis of raw and composted groundnut shell and toddy palm shell.
- To assess the effect of bio-compost on the growth and yield parameters of selected crops such as bhendi, cluster bean, coriander and fenugreek.
- To estimate the biochemical parameters of selected plants in different treatments of agricultural wastes.
- To analyze the pre and post harvested soil of selected plants.
- To evaluate the influence of effective microorganisms and coir pith under field culture.
- To study the growth, yield, biochemical attributes and soil nutrient status of bhendi, cluster bean, coriander and fenugreek under the best treatment.

MATERIALS AND METHODS

The methodology consists of four phases

PHASE I

1. Composting

1.1 Collection of samples

The agricultural residue groundnut shell was obtained from groundnut field, Pollachi and toddy palm shell was collected from roadside litter zones and toddy palm vendor shops in and around the city of Coimbatore, Tamil Nadu. *Paecilomyces variotti*, *Bacillus licheniformis*, *Pleurotus florida* and *Streptomyces lavendulae* were collected from the Institute of Microbial Technology, Chandigarh and *Trichoderma asperelloides* was collected at Tamil Nadu Agricultural

University, Coimbatore. The tiger worm *Eisenia fetida* was collected from Selvam Eyarkai Angadi at Udumalpet.

1.2 Composting treatments

C_1 - Groundnut shell + *Trichoderma asperelloides* + *Eisenia fetida*

C_2 - Groundnut shell + Microbial consortium

C_3 - Groundnut shell + Microbial consortium + *Eisenia fetida*

C_4 - Toddy palm shell + *Trichoderma asperelloides* + *Eisenia fetida*

C_5 - Toddy palm shell + Microbial consortium

C_6 - Toddy palm shell + Microbial consortium + *Eisenia fetida*

1.3 Process of composting

Composting was performed in pit method at Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, Tamil Nadu, India located at 76.9504° E and 11.0196° N. The study consists of six composting pits named C_1, C_2, C_3, C_4, C_5 and C_6 (C standard for compost) and each pit measured at 0.9m length, 0.6m width and 0.5m depth. 20 kg of dried groundnut shell was transferred into C_1, C_2, C_3 and toddy palm shell was transferred into C_4, C_5 and C_6 along with animal manure (cow dung). Addition of 80 g of *Trichoderma asperelloides* into C_1, C_4 and the mixture of about 400 g of the consortium of microorganisms and cow dung slurry was sprayed into C_2, C_3, C_5 and C_6 homogeneously spread over like a sandwich. Sprinkled water to prevent drying and it was thoroughly mixed once a week. After one month the groundnut shell and toddy palm shell were partially decomposed which is suitable for earthworm feeding. C_1, C_3, C_4 and C_6 composts were transferred into the plastic trays measuring 50×35×15cm (length, width and depth). Holes were made at the bottom of the tray to drain the excess amount of water. Healthy epigeic earthworm (*Eisenia fetida*) was inoculated into the plastic trays containing respective samples. The trays were kept undisturbed in a shaded area for 60 days, maintaining a moisture level of around 75%. At the end of the composting, it turns dark brown to a black color and the earthworms were separated by sieving. During the decomposition of the groundnut shell and toddy palm shell the regular intervals of 30^{th}, 60^{th} and 90^{th} days the microbial population (bacteria, fungi and actinomycetes) was analyzed.

1. Physicochemical parameters

- pH
- EC
- Lignin (%) (Goering and Vasoest, 1975)
- Cellulose (%) (Updegroff, 1969)
- Organic carbon (%) (Humphries, 1956)
- Total nitrogen (%)
- Total phosphorus (%) (Jackson, 1973)
- Total potassium (%)
- Calcium and Magnesium (%)

2. Fourier transform infrared spectroscopy

3. X-ray diffraction method

4. Scanning electron microscopy

PHASE II

2. Field culture studies

2.2 Field preparation

The experimental plot was ploughed repeatedly by tractor to fine tilth. Ridges and furrows was opened at 30 cm distance. Field was divided into small plots about 4.6 m length and 1.4 m width according to the treatments and three replications with randomized block design. About 5 t/ha of prepared compost was incorporated into the soil depending on the treatments

2.3 Collection of seeds

Bhendi (CO 4), Cluster bean (MDU 1), Coriander (Co (CR) 4) and Fenugreek (Co 2) seeds were purchased from Tamil Nadu Agricultural University, Coimbatore.

2.4 Details of treatment

C - Control (without compost) (5 t/ha)

T_1 - Groundnut shell + *Trichoderma asperelloides* + *Eisenia fetida* (5 t/ha)

T_2 - Groundnut shell + Microbial consortium (5 t/ha)

T_3 - Groundnut shell + Microbial consortium + *Eisenia fetida* (5 t/ha)

T_4 - Toddy palm shell + *Trichoderma asperelloides* + *Eisenia fetida* (5 t/ha)

T_5 - Toddy palm shell + Microbial consortium (5 t/ha)

T_6 - Toddy palm shell + Microbial consortium + *Eisenia fetida* (5 t/ha)

2.5 Growth parameters

On 25, 50 and 75 DAS (bhendi, cluster bean, coriander and fenugreek) plants were uprooted from the field and the following vegetative characters were noted. Root length (cm), Shoot length (cm), Number of leaves, Number of branches, Diameter of leaf (cm), Number of flowers, Number of umbels, Number of nodules, Fresh weight of plant (g) and Dry weight plant (g) respectively.

2.6 Yield parameters

On 90 DAS the yield characters like Number of fruits/plant, Number of pods/plant, Length of fruit (cm), Length of pod (cm), Diameter of fruit (cm), Number of seeds/plant, Yield/plant (g), Yield/plot (kg), Yield/hectare (kg), Straw yield/ hectare, Fresh weight of fruit (g), Fresh weight of pod (g), Dry weight of fruit (g) and Dry weight of pod (g) was analyzed in the selected test crops respectively.

PHASE III

3.1 Biochemical analysis

- Carbohydrate (Hedge and Hofreiter, 1962)
- Protein (Lowry *et al.*, 1951)
- Chlorophyll (Arnon, 1948)
- Leghaemoglobin (Appleby and Bergersen, 1980)

3.2 Soil nutrient status

- pH
- EC
- Available Nitrogen (Kg/ha) (Subbiah and Asija, 1956)
- Available Phosphorus (Kg/ha) (Jackson, 1973)
- Available Potassium (Kg/ha) (Standford and English, 1949)

PHASE IV

4.1 Best treatment

Based on the growth, yield and biochemical analysis of field studies the T_6 (Toddy palm

shell + Microbial consortium + *Eisenia fetida*) gave the best results and the best treatment samples was compared with effective microorganisms and coir pith. The study was conducted during the period of January - April 2020 at Aalandhurai, Coimbatore.

4.2 Preparation of effective microorganisms

An equal amount (250 g) of pumpkin, papaya, banana and jaggery were crushed and mixed with one litre of distilled water and the mixture was transferred into an airtight container and kept in dark place for one month. At regular interval of three days the gas was released by loosening the bottle cap. After one month the mixture was fully fermented with sweet sour smell which was diluted with water in the ratio of 10 ml of solution in 1 litre of water.

4.3 Coir pith

Coir pith was brought from the nursery and it was soaked in the water for 30 minutes before use. Coir pith and compost (T_6) were applied before sowing the seed and effective microorganisms was sprayed after thinning the plant.

4.4 Treatment application

C - Control

T_1 - Coir pith (5t ha^{-1})

T_2 - Best treatment (Toddy palm shell + Microbial consortium + *Eisenia fetida*) (5t ha^{-1})

T_3 - Effective microorganisms (1L/m^2)

4.5 Growth parameters

Root length (cm), shoot length (cm), number of leaves, diameter of leaf (cm), number of flowers, number of umbels, number of nodules, fresh weight of plant (g) and dry weight of plant (g) were analyzed on 25, 50 and 75 DAS.

4.6 Yield parameters

Number of fruits and pods, length of fruit and pod (cm), diameter of fruit (cm), number of seeds, yield per plant (g), yield per plot (kg), yield per hectare (kg), straw yield per hectare, fresh weight of fruit and pod (g) and dry weight of fruit and pod (g) were analyzed on 90 DAS.

4.7 Biochemical characters

The protein (Lowry *et al*., 1951), carbohydrate (Hedge and Hofreiter, 1962), chlorophyll content (Arnon, 1949) and leghaemoglobin content (Appleby and Bergersen, 1980) were studied on 25, 50, 75 and 90 DAS.

4.8 Soil status

The pH, electrical conductivity, Available nitrogen (Subbiah and Asija, 1956), Available phosphorus (Jackson, 1973) and Available potassium (Standford and English, 1949) were analyzed before and after compost application and post-harvested soil.

4.9 Statistical Analysis

In the present study, the experimental findings are provided in the form of graphs (figure) and table with the help of Microsoft Excel (Version 2019) and Origin (Version Pro 8.5) software. The data obtained from the microbial population during composting, as well as various vegetative growth and biochemical characteristics of selected plants were statistically analyzed by two-way and yield parameters were statistically analyzed by one-way ANOVA using SPSS (Version Sigma Stat 3.1). The values are given in the respective tables and figures (graphs) in the chapter 4 of the thesis and the based on the results conclusion were drawn.

RESULTS AND DISCUSSION

PHASE I

The total bacterial, fungal and actinomycetes population were increased in all the treatments compared with the control. The highest number of colonies was noted in C_6 (toddy palm shell + microbial consortium + *Eisenia fetida*) on 60^{th} day of composting. During the thermophilic phase of composting the microbial count was increased. At the regular interval of 30 days (the cooling or maturation phase at 90 days) microbial load was slightly decreased due to the lack of nutrients and environmental conditions.

The physical and chemical parameters such as pH, electrical conductivity (ds/m), organic carbon (%), C: N ratio, total nitrogen (%), total phosphorus (%), total potassium (%), calcium (%), magnesium (%), lignin (%) and cellulose (%) were analyzed in six different compositions of composts and control (groundnut shell and toddy palm shell) to ensure the maturity of the compost.

Among the six compost treatments, the C_6 (toddy palm shell composted by microbial consortium and *Eisenia fetida*) achieved maximum reduction of organic carbon, C:N ratio, lignin and cellulose simultaneously increased the pH, EC, total nitrogen, total phosphorus, total potassium, calcium and magnesium followed by other treatments.

The maturity and quality of the compost was ensured by the reduction of lignin, cellulose, organic carbon and carbon nitrogen ratio. A considerable reduction was observed in C_6 with the help of ligninolytic and cellulolytic enzymes produced by lignocellulolytic microorganisms present in the consortium of microorganisms which would had the ability to degrade the organic amendments and improved the plant nutrients.

The FT-IR spectra of groundnut shell and toddy palm shell was compared with C_1, C_2, C_3, C_4, C_5 and C_6 composted samples. The spectral absorption showed the stretching and banding of vibrational bands of chemical groups observed in raw groundnut shell and toddy palm shell. The degradation of cellulose, hemicellulose and lignin was monitored by FTIR analysis due to the disappearance of the respective bands in C_3 (groundnut shell + microbial consortium + *Eisenia fetida*) and C_6 (toddy palm shell + microbial consortium + *Eisenia fetida*) composted samples.

XRD results revealed that the degradation of lignocellulosic compounds in the bio-composted samples. In the present study, raw groundnut shell compared with C_3 (groundnut shell decompose with the help of microbial consortium and *Eisenia fetida*) and toddy palm shell compared with C_6 (toddy palm shell decompose with the help of microbial consortium and *Eisenia fetida*) respectively. A broad hump and sharp peak obtained in the raw materials which was disappeared in the processed composted samples (C_3 and C_6) indicates the degradation of cellulose and lignin. Scanning electron microscopic images of groundnut shell and toddy palm shell showed the presence of cellulose microfibers which completely disappeared in C_3 and C_6 composts due to the breakdown of cellulose and lignin compounds by lignocellulolytic enzymes produced by lignocellulolytic microorganisms present in the consortium of microorganisms.

PHASE II

The prepared composts (C_1, C_2, C_3, C_4, C_5 and C_6) were applied in the field as a treatment of T_1, T_2, T_3, T_4, T_5 and T_6 to evaluate the growth (on 25, 50 and 75 DAS) and yield (on 90 DAS) performance of bhendi, cluster bean, coriander and fenugreek. In the present study, significantly

increased root length, shoot length, number of leaves and diameter of leaf were recorded in T_6 followed by T_3 compared to the C on 25, 50 and 75 DAS in bhendi. A remarkable increase in number of flowers was observed in T_6 followed by T_3, T_5, T_2, T_1, T_4 than C on 50 and 75 DAS respectively. Fresh weight and dry weight of bhendi was increased with the application of toddy palm shell decomposed by microbial consortium and *Eisenia fetida* (T_6) followed by T_3 (groundnut shell + microbial consortium + *Eisenia fetida*) than control on 25, 50 and 75 days after sowing.

The root length, shoot length, number of leaves and number of nodules were observed maximum in T_6 (toddy palm shell + microbial consortium + *Eisenia fetida*) followed by T_3 (groundnut shell + microbial consortium + *Eisenia fetida*) than control on 25, 50 and 75 DAS. On 75 DAS the decline of root nodules in cluster bean was noted in all the treatments than 25 and 50 DAS. However, maximum number of root nodules observed in T_6 followed by T_3, T_5, T_4, T_2, T_1 and C. The combined application of toddy palm shell bio-composted by using microbial consortium and earthworm (T_6) enhanced the number of flowers on 50 and 75 DAS followed by T_3, T_5 and C. Significantly increased fresh and dry weight of cluster bean was recorded in T_6 followed by T_3, T_5, T_2, T_4, T_2, T_1 compared with C on 25, 50 and 75 days after sowing.

The toddy palm shell decomposed with the help of microbial consortium and *Eisenia fetida* (T_6) enhanced the root length, shoot length, number of branches, fresh and dry weight of coriander followed by T_3 than C on 25, 50 and 75 DAS. Maximum number of umbels in coriander was influenced by T_6 followed by T_3, T_5 compared with other treatments on 50 and 75 days after sowing. Root length, shoot length, number of leaves and number of nodules in fenugreek were maximum in T_6 followed by T_3 compared to the control on 25, 50 and 75 DAS. On 50 and 75 DAS the number of flowers in fenugreek improved with the application of T_6 followed by T_3, T_5, T_2 than other treatments. The toddy palm shell decomposed by the joint action of microbial consortium and *Eisenia fetida* (T_6) achieved maximum fresh weight and dry weight of fenugreek followed by T_3, T_5 when compared with other treatments on 25, 50 and 75 days after sowing.

In the present study, the number of fruits, length of fruit (cm), diameter of fruit (cm), number of seeds/fruit, yield/plot (kg), yield/ha (kg), fruit fresh weight (g) and fruit dry weight (g) of bhendi were maximum in T_6 (toddy palm shell + microbial consortium + *Eisenia fetida*) followed by T_3 (groundnut shell + microbial consortium + *Eisenia fetida*), T_5 (toddy palm shell + microbial consortium) than C (control) on 90 DAS. The application of toddy palm shell

decomposed with the help of microbial consortium and *Eisenia fetida* (T_6) improved the number of pods, length of pod (cm), number of seeds/pod, yield/plant (g), yield/plot (kg), yield/ha (kg), pod fresh weight (g) and pod dry weight (g) of cluster bean followed by T_3 when compared to the other treatments and control on 90 days after sowing.

Significantly increased number of seeds/plant, yield/plant (g), yield/plot (kg), yield/ha (kg), straw yield/ha (kg), seeds fresh weight (g) and seeds dry weight (g) of coriander were influenced by the application of toddy palm shell composed by using microbial consortium and earthworm (T_6) followed by T_3, T_5, T_4, T_2, T_1 and C on 90 DAS. On 90 DAS the number of pods, length of pod (cm), number of seeds/pod, yield/plant (g), yield/plot (g), yield/ha (kg), straw yield/ha (kg), seeds fresh weight (g) and seeds dry weight (g) of fenugreek was improved with the application of bio-composted toddy palm shell by using microbial consortium and *Eisenia fetida* (T_6) when compared with other treatments.

The vegetative and yield parameters of bhendi, cluster bean, coriander and fenugreek were improved by T_6 which may be due to the availability of nutrients supply from the organic compost. Organic manure incorporated into the soil enhanced the soil physical and chemical properties which enhanced the plant growth and development through boosting soil physico-chemical and biological properties. In the current study, the compost (C_6) the treatment - T_6 (toddy palm shell + microbial consortium + *Eisenia fetida*) achieved good quality and maturity of the compost thereby increasing the vegetative and yield characteristics of test crops.

PHASE III

On 25, 50 and 75 DAS the carbohydrate, protein, chlorophyll a, chlorophyll b and total chlorophyll content in leaves of bhendi, cluster bean, coriander and fenugreek were analyzed. The leghaemoglobin content in root nodules of cluster bean and fenugreek were evaluated on 25, 50 and 75 days after sowing. In the current study, maximum carbohydrate, protein, chlorophyll a, b and total chlorophyll content in the leaves of selected test crops and leghaemoglobin content in root nodules of cluster bean and fenugreek was influenced by T_6 (toddy palm shell + microbial consortium + *Eisenia fetida*) followed by T_3 as compared to the control.

The carbohydrate and protein content in fruits of bhendi, pods of cluster bean, seeds of fenugreek and coriander was enhanced with the application of toddy palm shell + microbial

consortium + *Eisenia fetida* (T_6) followed by T_3 as compared to the C on 90 DAS. The increase in the biochemical content might be due to the application of organic manure would have enhanced the physiological and metabolic activities in the plant tissue.

The physical and chemical properties of experimental field soil before the addition of compost was low. The value of soil pH, electrical conductivity (dS/m), available nitrogen (Kg/ha), available phosphorus (Kg/ha), available potassium (Kg/ha) were significantly increased by the addition of compost. In the present study, the co-inoculation of toddy palm shell decomposed with the help of microbial consortium and *Eisenia fetida* (T_6) improved the soil pH, EC, available nitrogen, available phosphorus and available potassium level.

After harvest stage of bhendi, cluster bean, coriander and fenugreek the post-harvest soil properties of pH, EC, available nitrogen, available phosphorus and available potassium content were improved by the application of T_6 and minimum observed in C. However, a decline in electrical conductivity of bhendi was noted and maximum reduction obtained in T_6 followed by T_5, T_4, T_1, T_2, T_3 as compared to the C. The application of toddy palm shell composed by using microbial consortium and earthworm (T_6) significantly improved the soil physical and chemical properties of bhendi, cluster bean, coriander and fenugreek in post-harvest soil.

PHASE IV

Among the six treatments the T_6 (toddy palm shell + microbial consortium + *Eisenia fetida*) showed best results in vegetative, yield, biochemical and soil characteristics as compared with other treatments and control. In the current study, the treatment T_6 compared with market available product (coir pith) and effective microorganisms in field trial of the same four test crops.

On 25, 50 and 75 DAS the root length and diameter of leaf showed maximum in T_1 (coir pith) and the shoot length, number of leaves, number of flowers, fresh and dry weight of bhendi was maximum in T_3 (effective microorganisms) and minimum in C (control) respectively. The application of coir pith (T_1) enhanced the shoot length, number of leaves, number of flowers and the effective microorganisms improved the root length, number of nodules, fresh and dry weight of cluster bean followed by T_2, T_1 than C on 25, 50 and 75 days after sowing. The length of root and number of branches were influenced by the application of coir pith (T_1) and shoot length, number of umbels, fresh and dry weight of coriander was increased by T_3 followed by T_2, T_1 as compared to the C on 25, 50 and 75 DAS. The application of effective microorganisms (T_3)

improved the root length, number of flowers and coir pith (T_1) improved the shoot length, number of leaves, number of nodules, fresh and dry weight of fenugreek followed by T_2, T_3 than control on 25, 50 and 75 DAS.

Significantly increased number of fruits, yield/plant, yield/plot, yield/ha, fruit fresh weight and fruit dry weight were enhanced by the application of effective microorganisms (T_3) and length of fruit, diameter of fruit and number of seeds/fruit was influenced by coir pith (T_1) than control on 90 DAS in bhendi. Yield attributing characteristics (number of pods, length of pod, number of seeds/pod, pod fresh weight and pod dry weight) of cluster bean showed maximum in T_1 (coir pith) and yield/plant, yield/plot and yield/ha were obtained in effective microorganisms (T_3) followed by T_2 compared with C on 90 DAS. The influence of effective microorganisms (T_3) enhanced the number of seeds/plant, yield/plant, yield/plot, yield/ha, straw yield/ha, seeds fresh weight and seeds dry weight of coriander and number of pods, length of pod, number of seeds/pod, yield/plant, yield/plot, yield/ha, straw yield/ha, seeds fresh weight and seeds dry weight of fenugreek followed by T_2, T_1 than C on 90 DAS.

Carbohydrate content was significantly increased in T_1 (coir pith) followed by T_2 (toddy palm shell + microbial consortium + *Eisenia fetida*), T_3 (effective microorganisms) than C (control) on 25, 50 and 75 DAS in leaves of bhendi, cluster bean, coriander and fenugreek respectively. Protein content remarkably increased in leaves of bhendi, cluster bean and coriander in T_3 (effective microorganisms) and fenugreek was observed in T_1 than control on 25, 50 and 75 days after sowing. Chlorophyll a, chlorophyll b and total chlorophyll content in leaves of bhendi, coriander and fenugreek increased significantly with the application of effective microorganisms (T_3) and the cluster bean was influenced by coir pith (T_1) on 25, 50 and 75 DAS than other treatments. On 25, 50 and 75 DAS the leghaemoglobin content in root nodules of cluster bean, fenugreek and on 90 DAS the carbohydrate and protein content in fruits of bhendi, pods of cluster bean and seeds of coriander, fenugreek were enhanced by the application of coir pith (T_1) followed by T_2 (toddy palm shell + microbial consortium + *Eisenia fetida*), T_3 (effective microorganisms) as compared to the C (control) respectively.

Addition of compost (T_6), coir pith and effective microorganisms into the soil increased the value of pH, electrical conductivity, available nitrogen, available phosphorus and available potassium content than initial value of soil. The post-harvest soil of bhendi showed maximum pH

and available nitrogen in T_3 and EC, available phosphorus and available potassium was found to be maximum in T_1 than C. The value of EC, available nitrogen, available phosphorus and available potassium in post harvest soil of cluster bean and fenugreek were improved by the addition of coir pith (T_1) and the pH value was enhanced by the application of effective microorganisms as compared to the control in both cluster bean and fenugreek plants. In coriander, maximum value of pH and electrical conductivity was observed in T_3 and the available N, P and K content were observed in T_1 followed by T_2 and minimum in C respectively.

CONCLUSION

The present research brightens the possibilities of using groundnut shell and toddy palm shell in enhancing the crop growth and productivity. The bio-composted groundnut shell and toddy palm shell produced by using *Trichoderma asperelloides*, microbial consortium and *Eisenia fetida* improved the quality of the compost thereby enhanced the biometric, yield, biochemical and soil nutrient status of bhendi, cluster bean, coriander and fenugreek. The enhancement in growth and yield parameters of test crops may be due to the synergistic interaction of the constituents present in the bio-composted toddy palm shell by microbial consortium along with *Eisenia fetida*.

The present research not only can be viewed as an alternate solution for the disposal of groundnut shell and toddy palm shell waste but also minimizes the application of chemical fertilizers to crops and encourage organic farming. Good organic fertilizer obtains all necessary micro and macronutrients which is a key to enhance sustainability and productivity of crops. Well bio-composted organic matter applied in the right soil would not only improves moisture condition and the structure of the soil but also provide the crop necessary resistance against pest and disease. To conclude the integrated management of groundnut shell and toddy palm shell converted as an organic fertilizer in different combination improved the vegetative and yield parameters of the test crops Bhendi (*Abelmoschus esculentus* (L.) Moench Var. Co 4), Cluster bean (*Cyamopsis tetragonoloba* (L.) Taub Var. MDU 1), Coriander (*Coriandrum sativum* Var. Co (CR) 4) and Fenugreek (*Trigonella foenum-graecum* (L.) Var. Co 2).

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